Chapter 11

Lecture Outline*

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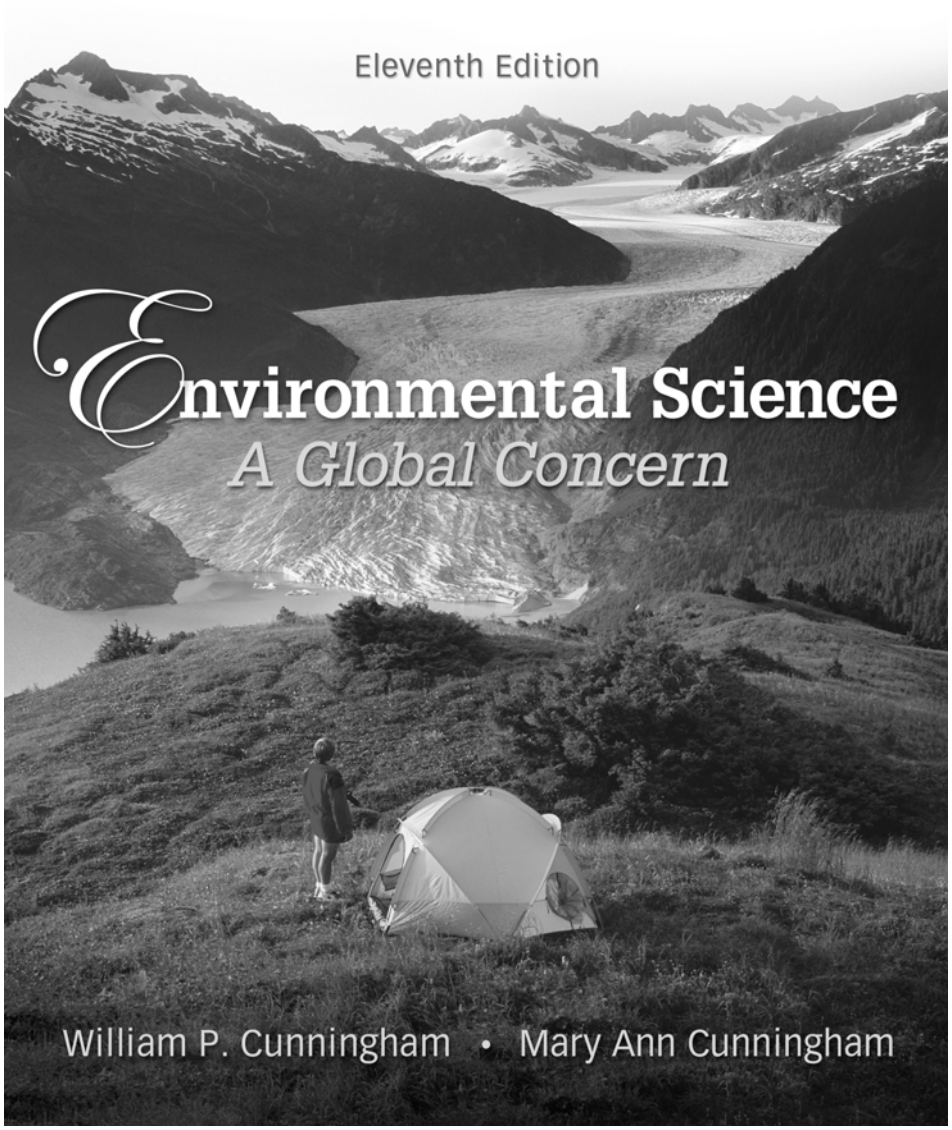
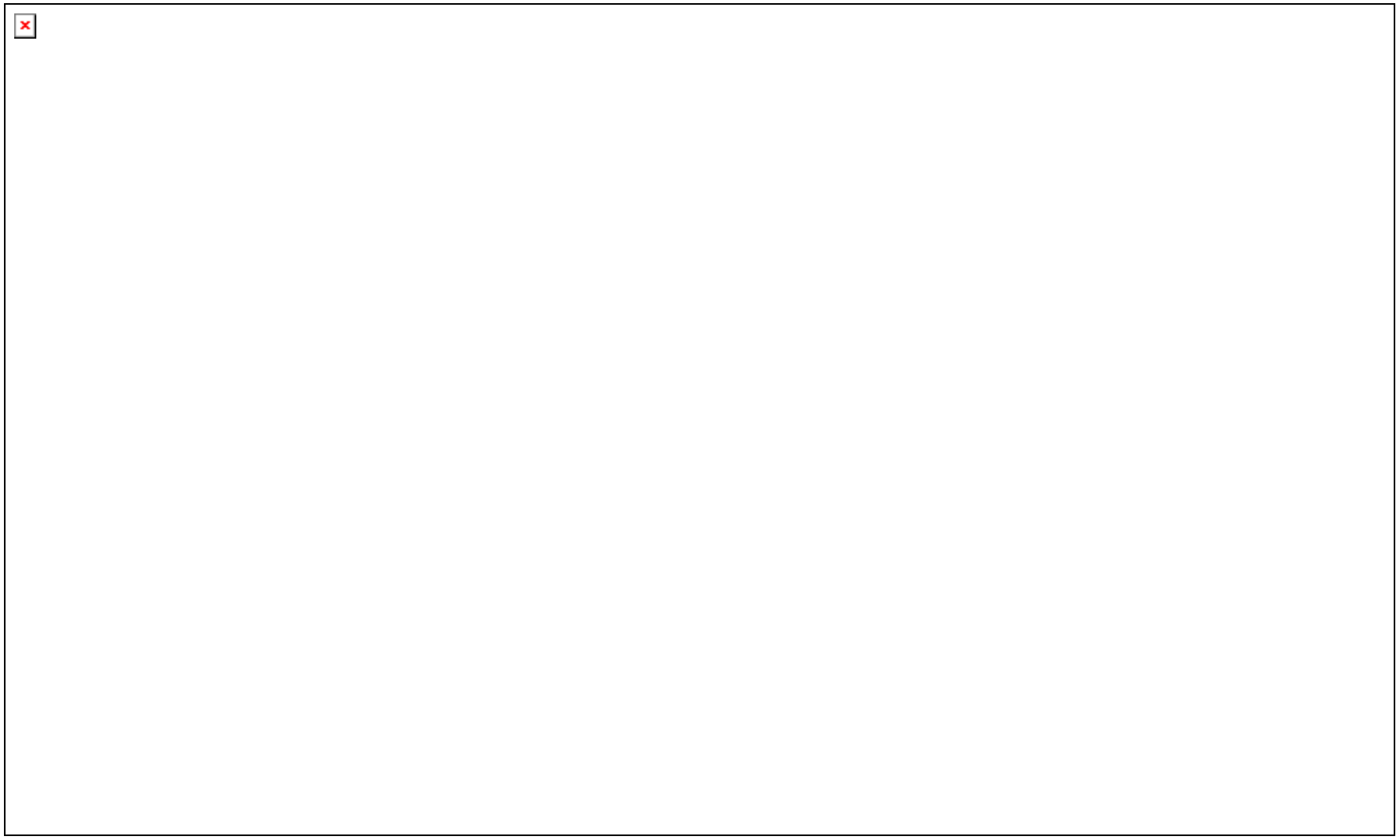


***See PowerPoint Image Slides for all figures and tables pre-inserted into PowerPoint without notes.**

Biodiversity: Preserving Species



Outline

- Biodiversity and the Species Concept
  - Varied Definitions
- Benefits of Biodiversity
- Threats to Biodiversity
  - Natural and Human-Caused Reductions
- Endangered Species Management
  - ESA
  - CITES
- Captive Breeding

Biodiversity of the Species Concept

- What is Biodiversity?
  - Genetic Diversity - measures variety of different versions of same genes within a species
  - Species Diversity - measures number of different kinds of organisms within a community
  - Ecological Diversity - measures richness and complexity of a community

What is Biodiversity?

- Species Diversity
  - Species Richness - total number of species in a community
  - Species Evenness -relative abundance of individuals within each species

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What Are Species?

- Species definitions
  - Reproductive isolation - organisms that breed in nature and produce fertile offspring
  - Phylogenetic species concept - emphasizes the cladistic relationships (branches on a taxonomic tree)
  - Evolutionary species concept - defines species in terms of evolutionary history

Molecular Techniques

- DNA sequencing and other molecular techniques give insight into taxonomic and evolutionary relationships.
  - Genome - total DNA sequence that characterizes a species
  - Species classification or even identification of an individual can be done from samples such as blood, fur, or feces.

How Many Species Are There?

- Currently 1.6 million species identified
- Estimates range between 3-50 million
  - Recent data support an estimate of 4 to 6 million insect species alone.
  - Invertebrates make up 76% of all known species, and probably most of yet to be discovered species.
- Tropical rainforests and coral reefs are biodiversity hotspots.
  - 34 hotspots (1.4% of world's land area) contain 75% of the world's most threatened mammals, birds and amphibians.

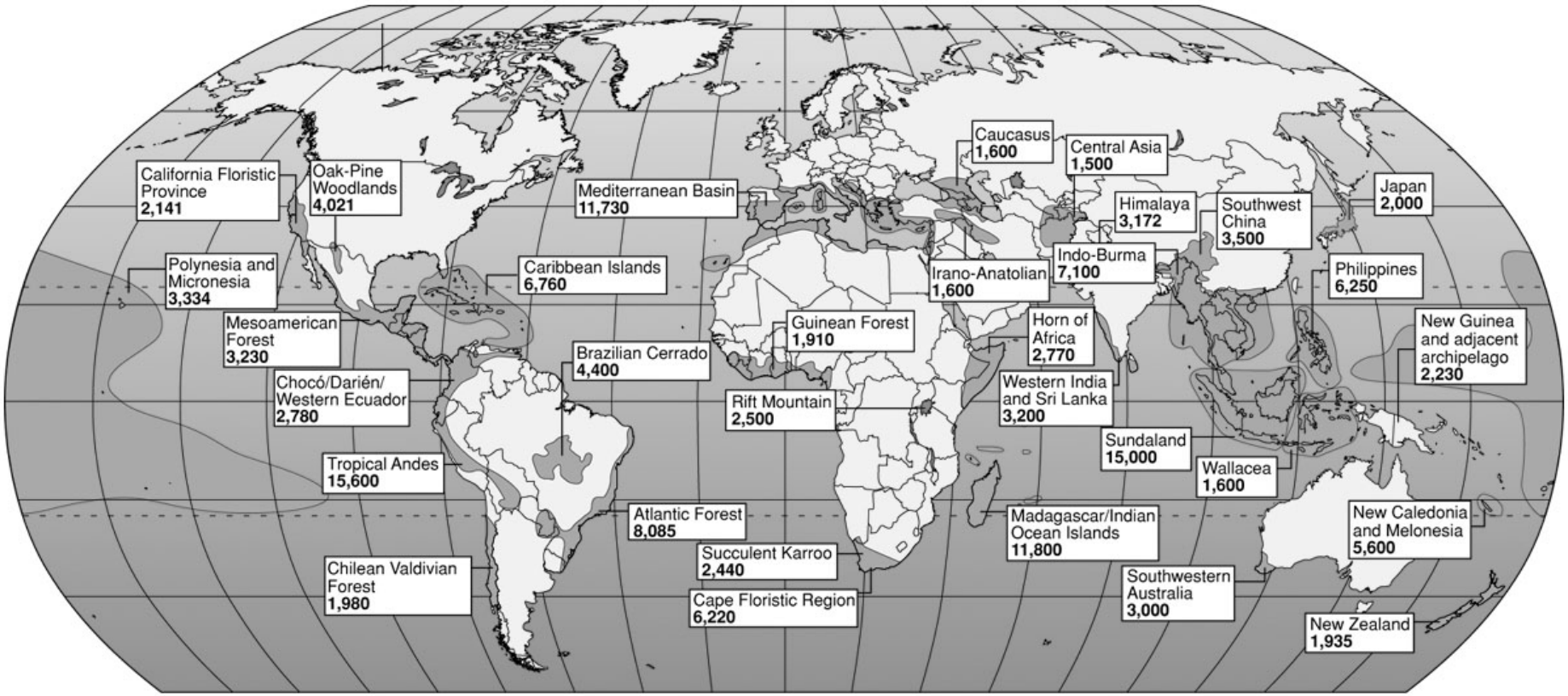
Known vs. Threatened Species

Table 11.1 Current Estimates of Known and Threatened Living Species by Taxonomic Group

	Known	Endangered and Threatened
Mammals	5,488	1,141
Birds	9,990	1,222
Reptiles	8,734	423
Amphibians	6,347	1,905
Fishes	30,700	1,275
Insects	950,000	626
Molluscs	81,000	978
Crustaceans	40,000	606
Other animals	161,384	283
Mosses	16,000	82
Ferns and allies	12,838	139
Gymnosperms	980	323
Dicotyledons	199,350	7,122
Monocotyledons	59,300	782
Lichens	17,000	2
Mushrooms	30,000	1
Algae	13,078	15
Total	**1,642,189**	**16,928**

Source: Data from IUCN Red List, 2008.

Biodiversity Hotspots



Benefits of Biodiversity

- Food
  - Wild plants could provide new sources of food or more genetic diversity for existing crops.
- Drugs and Medicines
  - More than half of all prescriptions contain some natural product.
  - Pharmaceutical companies actively prospect tropical countries for products.
  - Resources often extracted without compensation (biopiracy). Sharing profits provides an incentive to preserve native species.

Rosy Periwinkle makes anti-cancer drugs

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Benefits of Biodiversity

- Ecological Benefits
  - Soil formation, waste disposal, air and water purification, nutrient cycling, solar energy absorption, and biogeochemical and hydrological cycles all depend on biodiversity.
    - We do not fully understand biological communities. Loss of a seemingly insignificant species can be damaging.

Benefits of Biodiversity

- Aesthetic and Cultural Benefits
  - Hunting, fishing, camping, hiking, etc.
  - USFWS estimates Americans spend $104 billion annually on wildlife-related recreation.
  - Ecotourism can be an important form of sustainable economic development.
  - Existence (intrinsic) value - organisms have value in and of themselves.

Threats to Biodiversity

- Extinction - elimination of a species
  - Natural Causes
    - In undisturbed ecosystems, background rate appears to be one species per decade.
      - In this century, human impacts have accelerated that rate, causing perhaps hundreds to thousands of extinctions annually.

Natural Extinction

- Fossil record suggests more than 99% of all species ever in existence are now extinct.
- Periodically, the Earth has experienced mass extinctions.
  - Permian period - 95% of marine species and nearly half of all plant and animal families died out 250 million years ago.
  - End of Cretaceous - Dinosaurs and 50% of existing genera disappeared 65 million years ago.

Accelerating Extinction Rates

- Humans are accelerating the natural extinction rates by 100 to 1000x.
  - If present trends continue, half of all primates and one quarter of all bird species could go extinct within 50 years. Animals dependent upon them would also go extinct.
  - This is equivalent to other mass extinctions like the Cretaceous extinction.

Human-Caused Reductions in Biodiversity

- Acronym HIPPO summarizes the issues: habitat destruction, invasive species, pollution, population, and overharvesting.
- Habitat Destruction
  - Biggest reason for current increase in extinction is habitat loss
    - Conversion of forest to farmland, cities, etc.
      - Only 1/5 of remaining forest is old growth.
    - Habitat is fragmented into small, scattered plots
    - Loss of habitat due to mining, dams, destructive fishing practices

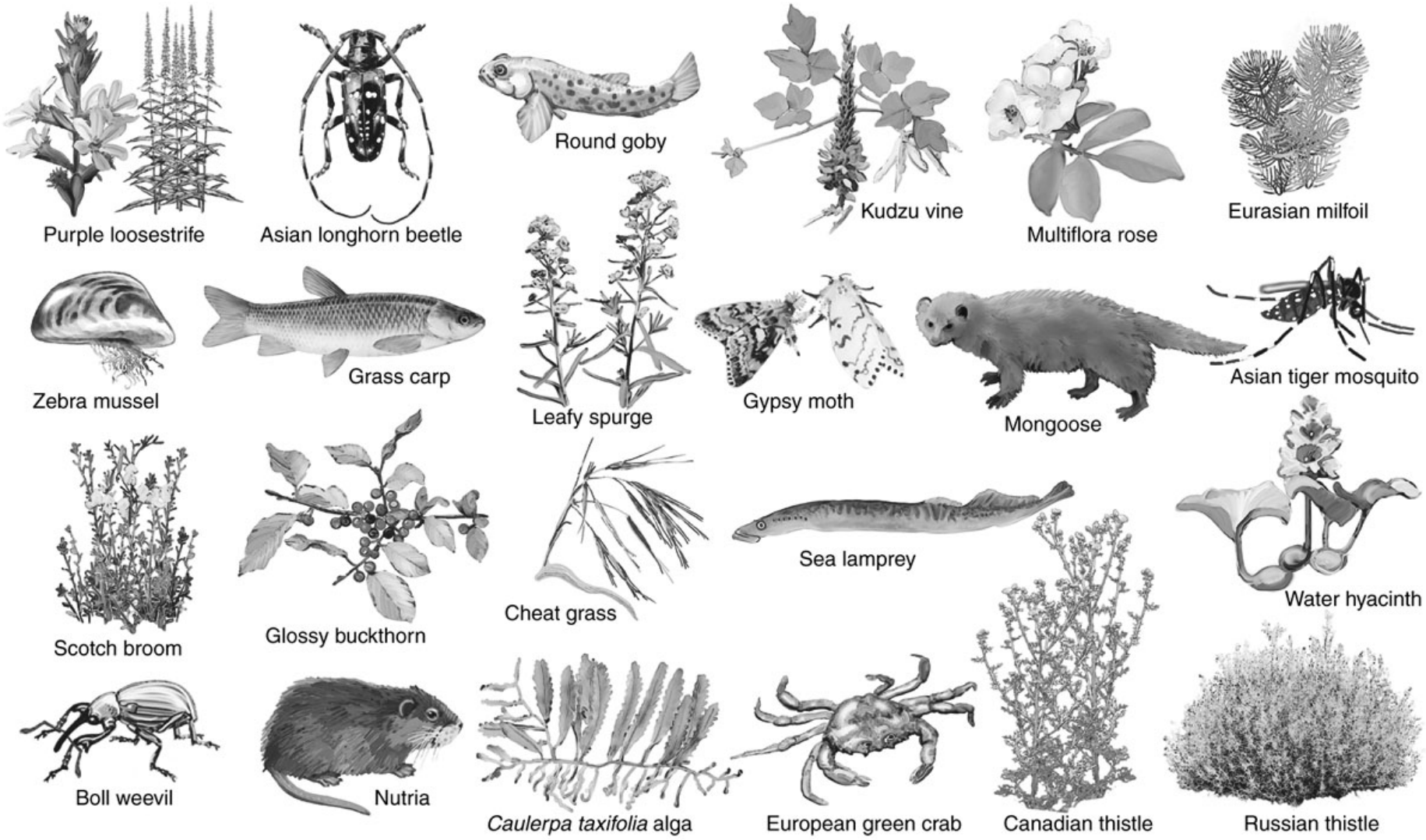
Human-Caused Reductions in Biodiversity

- Invasive Species
  - Invasive (exotic) organisms thrive in new territory where they are free of usual predators, diseases, or resource limitations that limited them in original habitat.
    - Over past 300 years, approximately 50,000 non-native species have become established in the U.S.
      - At least 4,500 are free-living.
        - 15% cause environmental damage.

Human-Caused Reductions in Biodiversity

- Examples of Invasive Species
  - Desert Barred Owl
  - Eurasian milfoil
  - Kudzu vine
  - Purple loosestrife
  - Zebra mussels
  - Chestnut blight
- Island ecosystems are particularly susceptible.
  - Example: New Zealand has lost 40% of its native flora and fauna since humans arrived.

North American Invasive Species



Human-Caused Reductions in Biodiversity

- Pollution
  - Pesticides
  - Lead
- Population
  - Human population growth and resource use
- Overharvesting
  - Passenger pigeon
  - All major fish stocks expected to collapse within 50 years
  - Bushmeat trade

Human-Caused Reductions in Biodiversity

- Commercial Products and Live Specimens
  - Wildlife smuggling is very profitable.
    - Fur, horns, live specimens, folk medicine
    - Leopard fur coat = $100,000
    - Mature cactus = $1,000
    - 5 million wild birds sold worldwide each year
      - Additional 3 million caught but die before reaching market
    - 128 million tropical fish sold annually in U.S.
      - Cyanide released above coral reefs to stun fish. A single diver can kill all life on 200 sq. meters of coral reef in one day.

Threats to Wildlife

(a) Bush meat market
© China Photos/Getty Images.

(b) Hyacinth macaws
© William P. Cunningham

(c) Cyanide fishing
© Lynn Funkhouser/Peter Arnold

a. More than 1 million wild animals are sold as meat each year
b. Hyacinth macaws are endangered by the pet trade
c. Cyanide fishing for aquarium fish endangers coral reefs

Endangered Species Management

- Hunting and Fishing Laws
  - By 1890's, most states had enacted some hunting and fishing laws.
    - General idea was pragmatic, not aesthetic or moral preservation.
    - In general, regulations have been extremely successful.
      - White tailed deer
      - Wild turkey
      - Snowy egret

Endangered Species Act

- Established in 1973
  - Endangered are those considered in imminent danger of extinction.
  - Threatened are those likely to become endangered, at least locally, in the near future.
  - Vulnerable are those that are naturally rare or have been locally depleted to a level that puts them at risk.

Endangered Species Act

- ESA regulates a wide range of activities involving endangered species:
  - Taking (harassing, harming, pursuing, hunting, shooting, killing, capturing, or collecting) either accidentally, or on purpose
  - Selling
  - Importing into or Exporting out of the U.S.
  - Possessing
  - Transporting or Shipping
- Prohibitions apply to whole organisms, body parts, and products made from the organisms.

Endangered Species Act

- Currently, U.S. has 1,264 species on its Endangered and Threatened lists, and about 386 candidate species waiting for consideration.
  - Number reflects more about human interests than actual status
    - Invertebrates make up 75% of all species, but only 9% of T/E list.
  - Listing process is extremely slow; at least 18 species have gone extinct since being nominated for protection.

Recovery Plans

- Once a species is endangered, USFWS is required to propose a recovery plan detailing the rebuilding of the species to sustainable levels.
  - Takes years, is expensive, and is subject to political interference
  - Once a species is endangered, much of its habitat and ability to survive is often compromised.

Recovery Plans

- Some endangered species merit special attention.
  - Keystone species - species has major effect on other members of community
  - Indicator species - tied to specific communities or successional stages
  - Umbrella species - require large blocks of undisturbed habitat
  - Flagship species - attractive organisms to which people react emotionally (Panda)
- Notable successes include bald eagle, peregrine falcons and the whooping crane

Recovery Plans

- Opponents have continually tried to require economic costs and benefits be incorporated into planning.
  - In 1978, construction of Tellico Dam in Tennessee threatened a fish called the snail darter. A federal committee was given the power to override the ESA for economic reasons.
  - Sometimes economic interests are in conflict. Commercial and sport fishing for salmon in Columbia River is worth 1 billion per year, but farmers and electric utilities want the dams that provide irrigation and hydroelectric power.

Private Land and Critical Habitat

- Eighty percent of habitat for more than half of all listed species is on non-public property.
  - Supreme Court has ruled destroying habitat equates to taking.
    - USFWS has been negotiating Habitat Conservation Plans (HCP) with private landowners.
      - Landowners allowed to harvest resources or build on part of land as long as endangered species benefits

ESA Success Story

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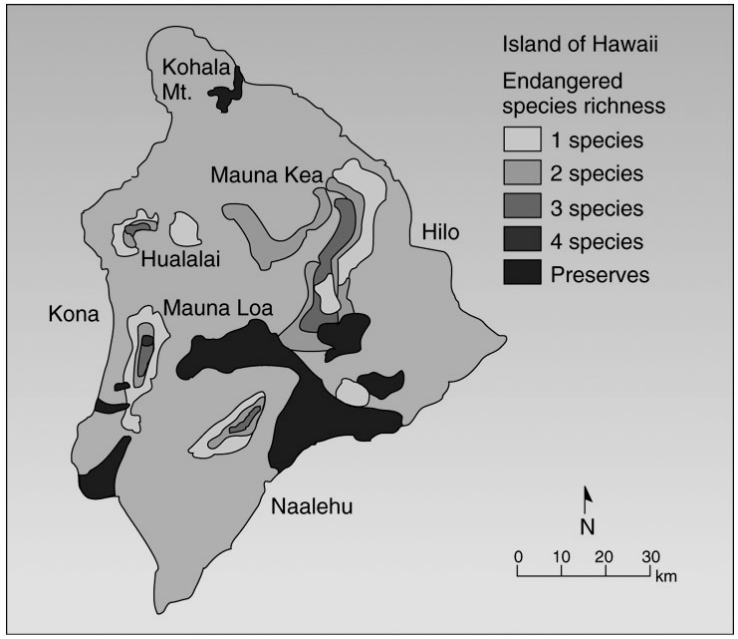
ESA is Controversial

- The ESA officially expired in 1992.
- Some peoples see it as a diabolical plot to take away private property and trample on individual rights.
- Farmers, loggers, miners, ranchers, developers and many other have tried to prevent its reauthorization.
- Some conservationists and scientists also have been critical of the ESA. They think we should focus on continent-wide preservation of ecosystems that support maximum biodiversity rather than on a few individual species on the brink of extinction.

Gap Analysis

- Gap analysis - seeks out unprotected landscapes rich in species
- This biodiversity map of the island of Hawaii shows areas of high species richness that are not protected in any preserve and preserves that have scenic and recreational value, but little in the way of species protection.



Habitat Protection

- Grumbine suggests 4 principles:
  - Protect enough habitat for all native species in a given region
  - Manage at regional scale large enough to accommodate natural disturbances
  - Plan over a period of centuries
  - Allow for human use at a level that does not result in significant ecological degradation

International Wildlife Treaties

- Convention on International Trade In Endangered Species (CITES) - 1975
  - Regulates trade in living specimens and products derived from listed species
  - Currently lists 700 species threatened with extinction by international trade

Captive Breeding

- Breeding programs in zoos and botanical gardens are one method of saving threatened species.
  - Repositories of genetic diversity
    - Most mammals in North American zoos are now produced from captive-breeding programs.
      - Reintroduction programs
      - But many species do not reproduce in captivity, and there are not enough zoos to maintain every species.

White Rhino: Captive Breeding Success

© Punchstock RF

Neem of Hawaii Restored by Captive Breeding

© William P. Cunningham

Captive Breeding

- Zoos have limited space
  - How many can/should we save? Should we preserve pathogens? Parasites?
  - Continued inbreeding of zoo specimens may lead to fertility and infant survival problems.
  - Natural habitat may disappear while we are busy conserving the species itself.
- Another alternative is to attempt to save species in the wild.
  - Provide funding for catching poachers and protecting species in their native habitats